APPLICATION NOTE

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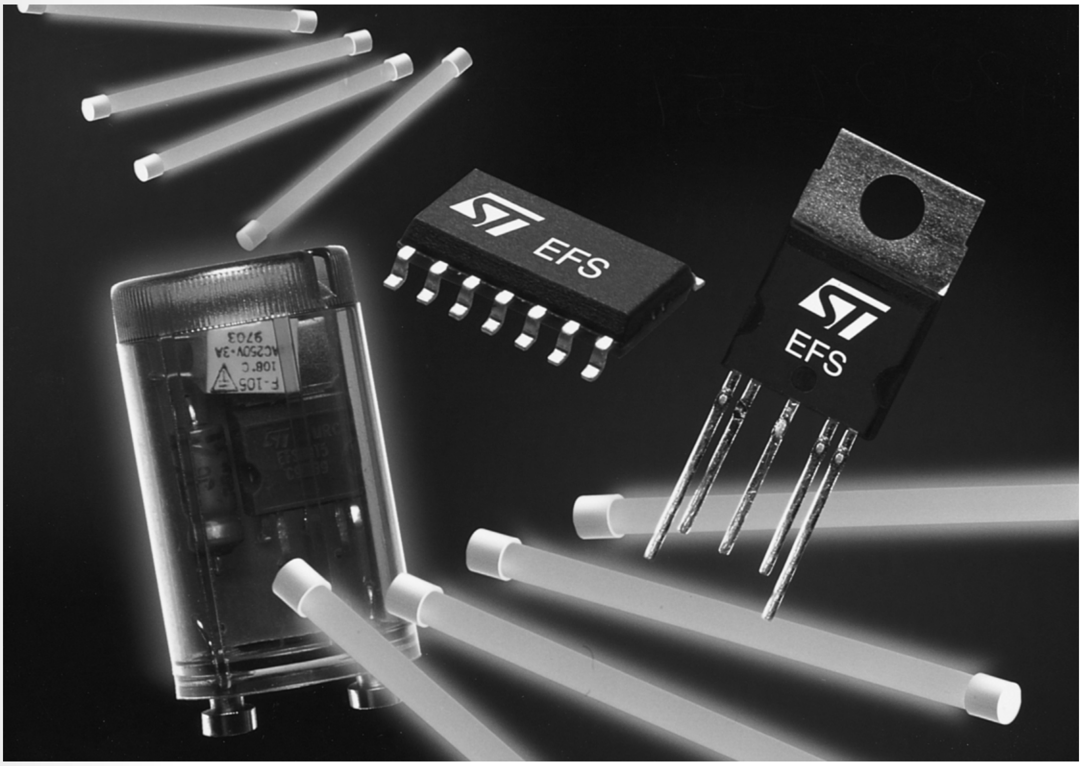
fluorescent lamp starter

2-chip set from SGS-Thomson



ST Electronics (formerly SGS-Thomson) have earlier this year brought out a 2-chip starter, the EFS (Starlight) Kit, which, in conjunction with four additional passive components, can be used as a direct replacement of the glow switch starter. The kit comprises a driver and an ASD™, which contains a power switch, and a power supply for the driver. The driver is programmed to ensure efficient ignition of the fluorescent tube.

An SGS-Thomson Application
Expanded by G. Kleine

INTRODUCTION

A low pressure fluorescent lamp normally consists of a glass tube, 38 mm in diameter and between 600 mm and 2400 mm long. The tube is filled with a noble gas at a pressure of not more than 4 per cent of atmospheric pressure and also contains a drop of liquid mercury. The interior surface of the tube is coated with phosphor which converts the ultraviolet light produced by the discharge into visible light.

At each end of the tube are electrodes that serve alternately as cathode and anode since these lamps are used in a.c. circuits.

The cathodes of a hot-cathode fluorescent lamp consist of a coiled filament coated with barium-oxide that is held

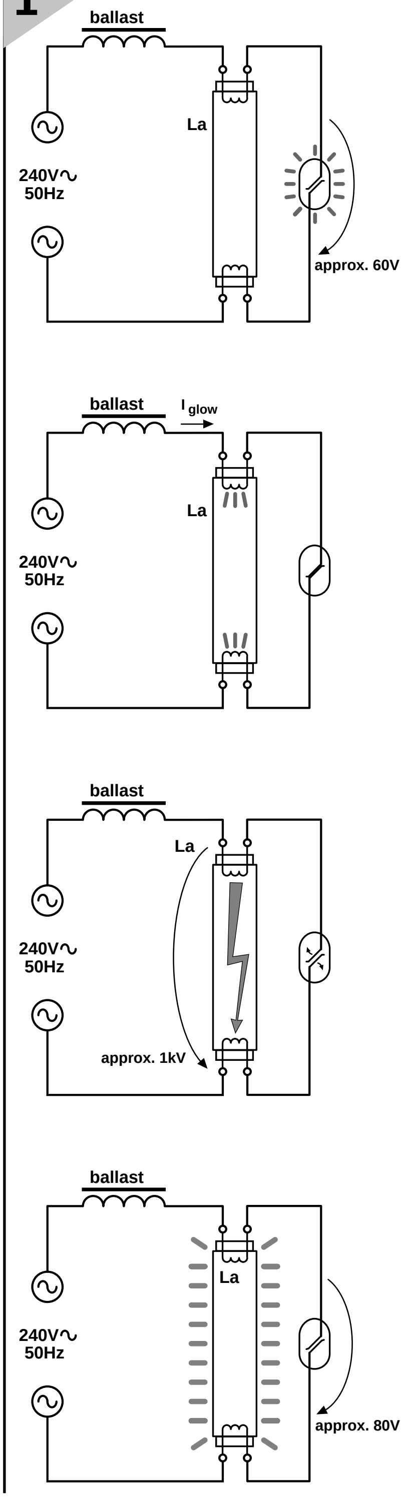


Figure 1. Operation of a fluorescent tube with traditional starter switch.

in place by nickel support wires.

Anodes in the form of metal strips or wires attached to the support wires are used in high-loading tubes, but in low-loading tubes the support wires act as anodes.

The noble gas serves to reduce the rate of evaporation of the barium from the cathode and also to reduce the starting voltage.

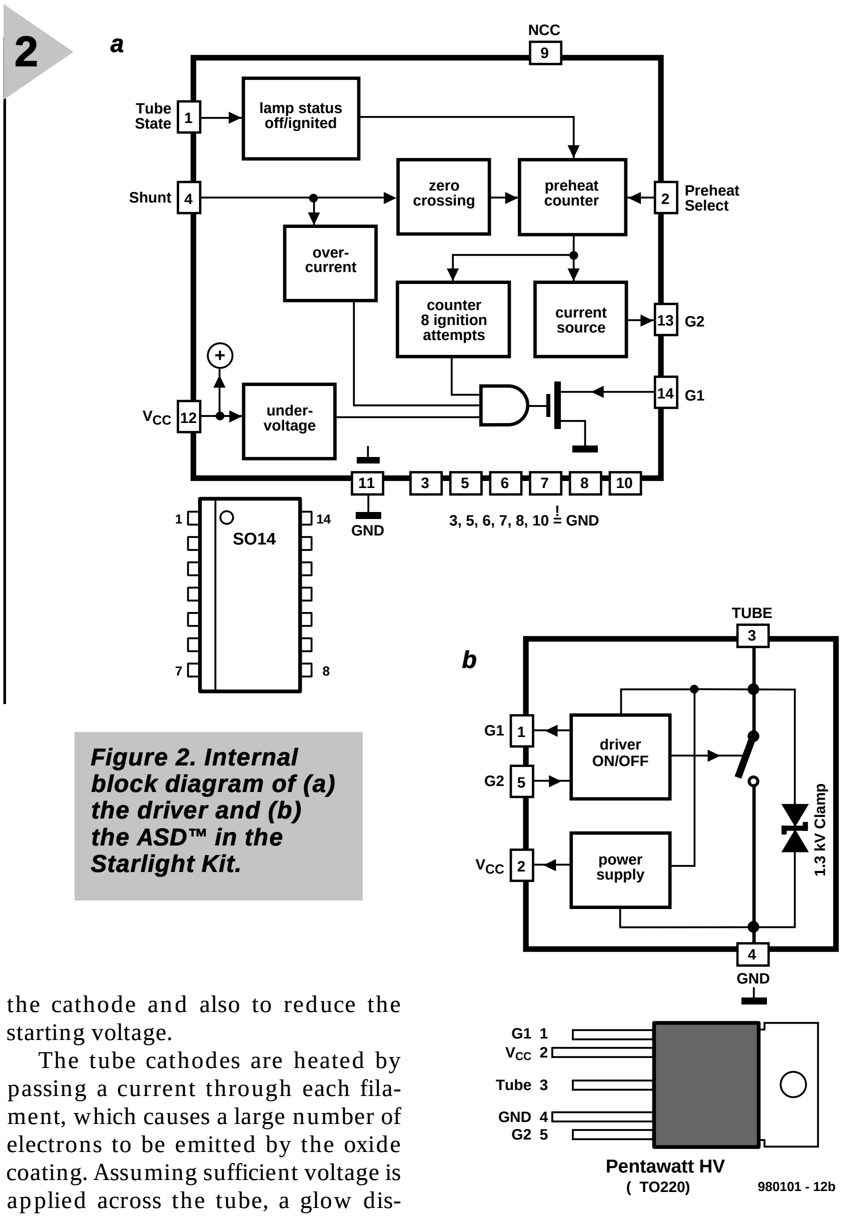


Figure 2. Internal block diagram of (a) the driver and (b) the ASD™ in the Starlight Kit.

The tube cathodes are heated by passing a current through each filament, which causes a large number of electrons to be emitted by the oxide coating. Assuming sufficient voltage is applied across the tube, a glow discharge is set up through the noble gas which excites or ionizes the mercury atoms throughout the tube and establishes a mercury-arc discharge.

A fluorescent tube requires a ballast (usually a choke) to limit the current through the tube, a starter for preheating the cathode filament. In many cases, this is complemented by a power-factor-correcting capacitor.

As the arc current increases, the voltage drop across the choke rises, so that the potential across the tube drops until a balance is reached.

The simplest and most frequently used starting device is the starter switch. When this is closed, a current flows through the ballast and the two cathodes in series, whereupon, as soon as the cathodes reach the emission temperature, local ionization is set up and the ends of the tube begin to glow. The starter switch is then opened rapidly, and the resulting change in current causes a large counter-e.m.f. across the coil, which is applied across the tube and is sufficient to cause the arc to strike.

The operations just described are illustrated in **Figure 1**.

Automatic starter switches permit a heating current to flow for a predetermined time before they open and produce the striking pulse. The traditional starting switch is a glow type, in which the switch contacts are mounted on bimetallic strips that bend towards each other when they are heated.

In many cases, bimetal starters have been, or are being, replaced by electronic starters. Current electronic starters for fluorescent lamps use a unidirectional switch, like a MOS transistor or GTO (Gate Turn Off) thyristor. Since a starter is a bidirectional switch it is necessary to use a rectifier bridge and, in addition, 2 or 3 diodes in series with the GTO to get the necessary switch-off effect. The whole switch is controlled with an analogue timer built around a small SCR (Silicon Controlled Rectifier). The switch in the new kit from ST Electronics is a bidirectional type, which substantially reduces the number of

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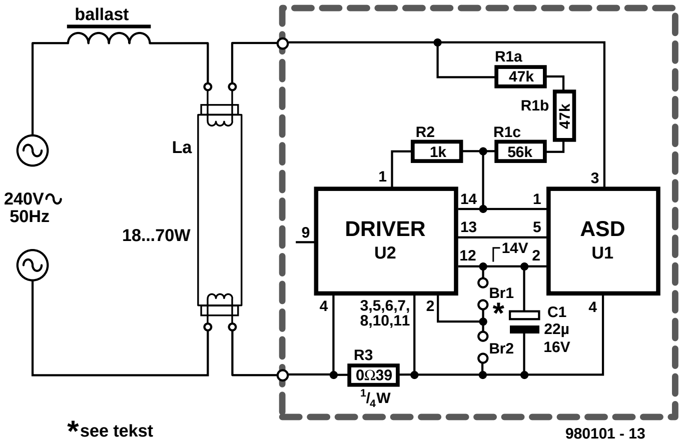

Figure 3. Basic application diagram of the EFS (Starlight) starter.

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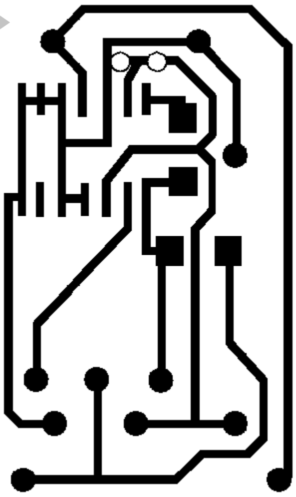

Figure 4. Track layout of the PCB for the Starlight Kit. (200%)

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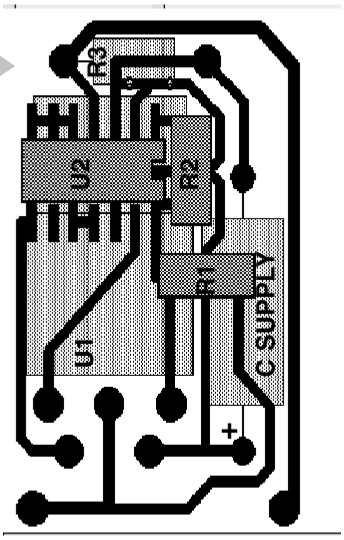

Figure 5. Component layout of the PCB for the Starlight Kit. (200%)

additional components and the power losses (only one forward voltage instead of 5 or 8 depending on the unidirectional version).

BASIC APPLICATION

A block diagram of the driver is shown in **Figure 2a**.

The bidirectional power switch performs two functions:

- preheating the tube;
- igniting the tube.

During the preheating period, the ASD™ conducts hard. The tube is short-circuited by the starter, and the current flows through its filaments. In this condition, the tube cannot light, but the temperature of the filaments rises steadily.

At the end of the preheating period, the filaments of the tube are hot enough to emit electrons into the gas and to permit the gas igniting. The ASD then switches off the preheating current. At that moment, the ballast is equivalent to a current generator where $I = I_{SO}$ (I_{SO} = switch-off current). While the ASD switches off, the starter voltage increases. The amplitude of this high-voltage spike is clamped by the ASD ($U_{BR} \approx$ 1350 V). Since the power switch and the tube are in parallel, the striking pulse is applied directly to the tube. The electromagnetic energy of the ballast is then discharged through the tube and the ASD™.

Recommended components:

R_1 = 150 kΩ, 1/2 W, SMD
R_2 = 1 kΩ or 2 kΩ (see text) 0.5 W SMD
R_3 = 0.39 Ω, 1/4 W
All resistors 5%

Capacitors:
C = 22 µF, 16 V, 10%

Integrated circuits:
See Table

The ASD contains an auxiliary power supply for the driver, a power clamping device (1350 V) and a bidirectional switch (**Figure 2b**).

A fluorescent tube requires a minimum level of energy to be ignited, but this energy depends largely on the temperature of the tube. The lower this temperature, the less energy, and the more difficult it is for the tube to ignite. The energy, E, stored in the ballast, L, is directly proportional to the I_{SO}:

$$E = LI_{SO}^2/2.$$

This means that the required energy, and thus the I_{SO}, is a maximum at the minimum temperature. Results based on experiments show that it is necessary to switch off a current of 350 mA to strike a 58 W tube at –20 °C (with the voltage clamped at 1300 V).

So, the best way for a tube to strike independently of temperature is to keep the I_{SO} at a maximum over the whole temperature range. In practice, the I_{SO} is maintained at 350 mA at temperatures below –10 °C and then allowed to drop gradually to about 180 mA at +75 °C.

AUXILIARY POWER SUPPLY

To reduce the number of components, an auxiliary power supply is incorporated in the ASD, which works directly from the mains. A capacitor at the output of the supply is charged at the beginning and end of each positive half-cycle of the mains voltage. During the preheat period, a part of the current flowing through the ASD is used to charge the output capacitor, so there is no line current distortion. When the tube is ignited, the capacitor is periodically recharged by the ASD to allow monitoring of the tube by the starter kit.

FUNCTIONAL DESCRIPTION

A functional diagram is shown in **Figure 3**. At switch-on, an integrated Under Voltage Lock Out (UVLO) function resets the driver as long as the supply voltage stays below a safe level.

The ignition sequence begins with the preheat period. Two different period lengths are available:

- if pin 2 is connected to ground, the preheat period is 1.5 s;
- if pin 2 is connected to V_{CC}, the preheat period is 2.5 s.

During the preheat period, the driver maintains the ASD in the full on state, making the starter equivalent to a closed switch.

At the end of the preheat period, the starter ignites the fluorescent tube. To this end, the driver continuously monitors the current through the starter. When the current reaches the switch-off level (350 mA), the driver turns off the ASD. This causes a high-voltage pulse to be induced across the tube, which is limited by the ASD breakdown voltage of 1350 V.

The driver senses the state of the tube (on or off). When the tube fails to strike and remains off for eight periods of the mains voltage, a new preheat period, shorter than the first, is begun, followed by a new ignition attempt. The driver will try to fire the tube eight times. If none of these attempts is successful, the driver is set to the standby mode, and the whole starter stops until the mains is switched off and then on again.

Once the tube is ignited, the driver stays in the standby mode, but continues to monitor the state of the tube. The ASD applies a short high-voltage pulse of 1 mJ at the beginning of each positive mains half-cycle. If the mains voltage drops briefly, the tube turns off momentarily, but the short pulse is sufficient to sustain the arc in the tube, so avoiding the need for a new ignition sequence.

During normal operation of the tube, the short pulse is masked by the tube conduction. If the mains is interrupted for some time, the lamp is switched off completely and a new ignition sequence is started as soon as the mains voltage is restored.

CONSTRUCTION

The complete starter may be built on the printed-circuit board shown in **Figures 4** and **5**. This fits nicely in the case of a defect glow type starter.

The components are SMD (surface-mount device) types. Start the soldering with the resistors, then the capacitor, and finally the two ICs.

The preheat time must then be set: pin 2 is the preheat time select pin. To select a 1.5 s preheat time, drill and cut the V_{CC} to pin 2 at the metallized hole. To select a 2.5 s preheat time, drill and cut the GND to pin 2. Either of these actions must be carried out to avoid a supply short circuit.

FINALLY ...

When the board has been fitted in a glow type starter case, insert it into the relevant connector on the tube holder. When the lamp is switched on, it should ignite at once. If it does not, lenghten the preheat time.

If increasing the preheat time does not help or if instead of the eight attempts at igniting the tube there is only one, the tube may have an integral series compensation capacitor as shown in **Figure 6**. In such a case, there is only one attempt at igniting the tube, but this should be sufficient.

There is an arrangement for two special tubes in series, the so-called twin tube configuration, as shown in **Figure 7**. This uses two starters, but only one ballast. The ST Electronics starter can be used in this arrangement if the value of R_2 is increased to 2 kΩ. If in this configuration the tubes do not ignite, turn one of the starters 180° in its socket.

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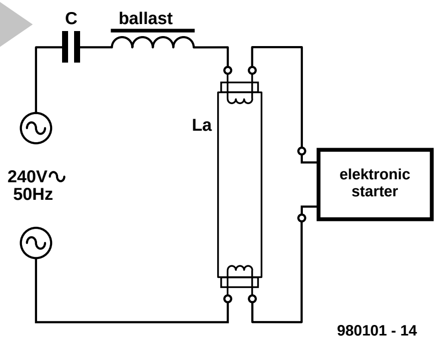

Figure 6. Some fluorescent tubes have an integral series compensation capacitor.

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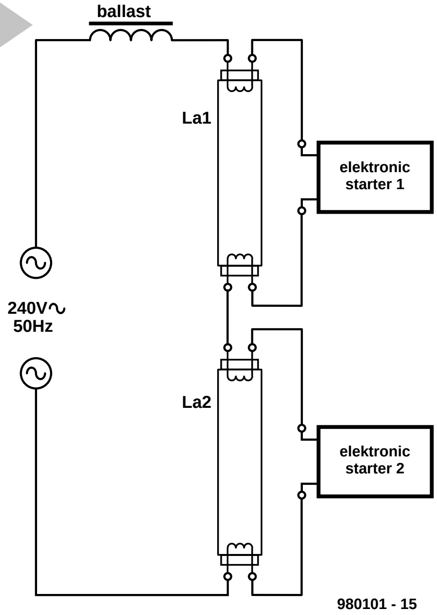

Figure 7. Twin tube configuration.

EFS Starlight Kit	*EFS1*	*EFS2*	*EFS3*
Tube rating (W)	*36–58*	*18–70*	*18–125*
Umgebungstemperatur [°C]	*5 to 75*	*–20 to 75*	*–40 to 85*
Twin tube serial connection	*Yes*	*Yes*	*Yes*
Driver (U_2)	*EFS1-A*	*EFS2-A*	*EFS3-A*
ASD™ (U_1)	*EFS1-1*	*EFS2-1*	*EFS3-1*